

## **Introduction by Scott Matyac, DWR**

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*by Scott Matyac, Department of Water Resources*

California farmers must find ways to continue profitable production in the face of a less abundant and increasingly costly water supply. At the same time, they are obliged to help maintain water quality by minimizing the leaching of salts and chemicals from the soil surface and root zone into the water supply. A key to better agricultural water management lies in improving our understanding of evapotranspiration, the process that drives crop water use. The articles in this section of the Reference Guide help to answer some questions on this important topic.

### What is evapotranspiration?

Crop water use is directly related to the water lost through the process of evapotranspiration (ET), a combination of evaporation from the soil surface and transpiration from plant leaves. The amount of water consumed through ET depends in the short term on local weather and in the long term on climatic conditions. Energy from solar radiation is the primary factor that determines the rate of crop ET. Also important are humidity, temperature, wind, stage of crop growth, and the size and aerodynamic roughness of the crop canopy. Irrigation frequency affects ET after planting and during early growth because evaporation increases when the soil surface is wet and exposed to sunlight. Growing season ET varies significantly among crop types, depending primarily on how long the crop actively grows.

### How is ET quantified?

Direct measurement of crop ET requires costly investments in time and sophisticated equipment. However, several new methods are available for estimating ET using local weather information and radiation data gathered by Earth orbiting satellites. In “Consumptive Use Program Model”, Orang and others describe a computer application for estimating crop ET in California. The model is in the form of a user-friendly MS-Excel spreadsheet that incorporates the latest crop coefficients and better accounts for evaporation from bare soil during the early growing season. “Simulation of Evapotranspiration of Applied Water” documents the work of Snyder and others to develop a weather generator model that simulates daily weather data from monthly climate data. The model, known by the acronym SIMETAW, shows promise for evaluating how climate change might affect crop ET and irrigation water needs in California. Other avenues of research include the use of satellite data to identify crop types and estimate crop ET. “Central Valley Crop Classification Processing Using Remote Sensing and GIS Technologies” details a cooperative effort by the U.S. Bureau of Reclamation and the California Department of Water Resources to remotely identify crop types with better than 90 percent accuracy. This method may prove to be a cost effective alternative to the current practice of “on-the-ground” surveys of cropping patterns. “Evapotranspiration from a satellite-based surface energy balance for the Snake River Plain Aquifer in Idaho” describes the development and application of METRIC<sup>TM</sup>, an image processing tool that combines data from Earth orbiting satellites and ground-based weather stations to estimate ET from crops, landscape, and native vegetation. METRIC<sup>TM</sup> has been applied on a limited basis in the Imperial Valley of California, and may be applicable to other important agricultural regions such as the Central Valley.

### **Should (and can) E and T be analyzed separately?**

Rainfall and irrigation water received by farmland is consumed by evaporation from the soil and transpiration from plant leaves. Though distinct, the two processes are usually analyzed collectively due to the difficulty in accounting for each process separately. Crop production is closely associated with transpiration because plants grow by assimilating carbon dioxide from the air via photosynthesis.

However, the water lost by evaporation does not directly benefit crop growth, raising the question of whether reducing evaporation might help to stretch California's agricultural water supply. In "Evaporation Research – a Review and Interpretation", Burt and others observe that the majority of annual evaporation is from rainfall and suggest that only a portion of evaporation may be conservable. They point out that transpiration decreases with increasing evaporation, but the tradeoff is not equal – the increase in E is typically greater than decrease in T. In a study supported by DWR, Hsiao and Xu studied the extent to which ET is suppressed while water is applied by sprinklers. Their article, "Evapotranspiration and Relative Contribution by the Soil and the Plant", discusses a method to estimate the extent to which crop T is likely to be increased by minimizing soil E. Ventura and others note that estimating vegetable crop ET is difficult because soil evaporation is high due to frequent irrigations. They also indicate that previous models for separately estimating E and T tend to require many crop and soil parameters that are not commonly available. Their article, "Model for Estimating Evaporation and Transpiration from Row Crops", describes the development of a model that better accounts for soil evaporation and requires only daily reference evapotranspiration as input.

In "Limits to the Productivity of Water in Crop Production", Keller and Seckler tackle the question "Will increased crop yields simultaneously create increased water scarcity because of increased transpiration?" They note that historical increases in crop yields have been accompanied by increased water productivity. However, they conclude that in highly developed agricultural areas the potential for substantial water savings is small and that yield increases will simultaneously increase transpiration and therefore contribute to water scarcity.

### **Can transpiration be reduced without harming agriculture?**

The close relationship between crop transpiration and photosynthesis is reflected in the near linear relationship between crop yield and crop ET. In most field and row crops, reducing transpiration through water stress is associated with reduced production in terms of crop quality or yield. In "The Promise of Regulated Deficit Irrigation in California's Orchards and Vineyards", Goldhamer and Fereres note that it is possible to reduce transpiration of trees and vines without reducing yield. They conducted Regulated Deficit Irrigation (RDI) research on the major tree crops in California – pistachio, olive, prune, and citrus – and identified numerous species where water can be saved without a negative impact on production or grower profit. RDI is already used by many California growers to stress trees or vines at specific developmental stages in order to improve crop quality, decrease disease or pest infestation, or reduce production costs. For example, mild stress is imposed on wine grapes through the growing season which decreases canopy growth and produces smaller berries with higher sugar content, better color, and higher skin to fruit-volume ratio. Further research may reveal the potential for orchard and vineyard RDI in managing California's agricultural water supply.

Evapotranspiration is the primary consumptive use of irrigation water and rainfall on agricultural land. The articles in this section document recent research that sheds new light on the interrelationships between evaporation, transpiration, and crop production. A common thread is that there remains considerable potential for translating increased understanding of crop water use into a more reliable and productive agricultural water supply.